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AVIATION AND AERONAUTICAL ENGINEERING

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Vol IX OCTOBER 15, 1920 No. 6

THE sixth race for the Gordon Bennett Aviation Cup, which resulted in the victory of the French defending team and France's permanent holdership of the famous trophy, should teach us a valuable lesson.

It is generally conceded that the American entries for the Gordon Bennett aviation race are faster machines than the French types which finished first and second Unofficial trials showed that our machines developed speeds around 200 m.p h., whereas the best speed made by the winning Nieuport, which is homologated as the world's record, is only 184 8 m.p.h. This speed record was made last December and was not equalled in the Gordon Bennett race, Sadi Lecointe's average speed being only 168 2 m p h.

Why then did our challengers fail to bring the Gordon Bennett Aviation Cup back to America? The answer is simple. Whereas the French Gordon Bennett machines were already being flown last winter, ours were designed, built and flight tested only a few months before the race As a consequence, while the French engineers had ample time in which to eliminate the infantile troubles every airplane displays on its trials, and the French pilots had likewise sufficient time to get the "feel" of their machine and the resulting confidence as to its performance, our engineers and pilots had very little chance to weed out the feeble points of our challengers

Such being the case, it is hardly astonishing that the Gordon Bennett Aviation Cup should have been won by France. The lesson is that insufficiently tested airplanes, though their performance may be superior to anything they are likely to meet in a contest, are liable to go down to defeat if the adversary has the advantage of better preparedness.

The Gordon Bennett Balloon Race

The Gordon Bennett balloon race which will be held at the end of this month at Birmingham, Ala, while less spectacular than the recent Gordon Bennett aviation race, promises to afford an interesting demonstration of the skill of the best balloonists of the United States, Belgium, France and Italy

American balloonists have so far won four of the eight contests for the Gordon Bennett Balloon Trophy, but as the American victories did not occur three times in succession the trophy has not yet come to this country for permanence. Individual skill is not always sufficient for the winning of a balloon race, for luck plays an important part in such contests. Hence, good luck to our balloonists.

Commercial Aeronautics

The outstanding attempts at running a non-government air transport service are the lines from London to Paris, Amsterdam and Brussels The service to Paris has been in operation under the same management for over a year and the other lines have been running throughout the summer. The success of the experiment was in doubt at the start of the summer, but it now seems assured in view of the tremendous increase in traffic during the last few months

The figures issued by the Air Ministry show that for the week of May 24 to 30 there were eighty-four flights in which a total of 138 passengers were carried On 38 trips additional load in the form of mail or express was aboard.

During the week of September 12 to 18, 128 flights were made and 295 passengers carried. In addition mail or express or both were carried on 87 of these flights. These data are very encouraging The gains in numbers of passengers, goods, and flights all indicate greater confidence by the public in this form of transportation Analyzing further, the figures show a state of affairs favorable to profits. The average number of passengers per flight has arisen from 1 6 in May to 2.3 in September, and the percentage of flights with goods or mail as well jumped from 45 to 68

The Handley Page Wing

An American patent was issued on September 21, 1920, to Frederick Handley Page on a new type of aerofoil which has for its object a high lift at large angles and a low resistance at small angles.

The result is accomplished by cutting a slot or series of slots in the wing near and parallel to the leading edge. These slots are at an angle of about minus thirty degrees to the wing chord, and prevent burbling at high angles. The lift coefficient is thereby allowed to increase beyond the usual burble point. At small angles of incidence it is advantageous to move the forward part of the wing back so as to close up the slot or slots. In this condition the aerofoil may have a low resistance shape Moving the leading edge forward at high angles to form a gap may be likened in effect to adding to the wing area by increasing the chord

The mechanical difficulties anticipated in applying this invention are not great and it remains only to find the best shape and arrangement of aerofoil and slots. As to the advantages which the new wing embodies, they promise to be sufficiently important to elicit keen interest among aeronautical engineers

Jet Propulsion

In view of the possibility of designing a power plant almost without moving parts, it is surprising that so little has been done with jet propulsion. The prospective reliability is very great. It would seem to be easy to change the direction of the propelling force. The jets might be distributed along the wing and thus apply the effect of slipstream over the whole surface to increase the lift. Experiments could possibly be carried out by harnessing the exhaust of the present internal combustion motor for the energy supply, thus avoiding the danger of depending on such a novel form of power for experimental work and allowing some of the attendant problems to be worked out in advance of a flight test with this source of power alone.

Used as an auxiliary means of propulsion in the combination with the motor, the overall efficiency might be improved. On account of its simplicity and flexibility, there are a great many uses to which this principle may be put, of which the above are but a few of the more obvious.

Dilatable Balloons

By James F. Boyle

Chief Engineer, Airship Mfg Co. of America, Hammondsport, N. Y

Recently there have been built and tested by the War Department several dilatable or expanding gore balloons. This type of balloon came to us from Europe.*

A dilatable balloon is, as its name implies, a balloon which is capable of dilating. That is, it can expand and contract with the variations of atmospheric pressure which causes variations of the volume of the filling.

Expansion and Contraction of Balloon Gas

As a rule all non-rigid or semi-rigid balloons which utilize as their lifting medium hydrogen gas or other light gas, are confronted with the problem of having a container for the gas which shall be capable of expansion and contraction to a degree great enough to take care of the change in volume of the filling which is caused by the variations in atmospheric pressure, temperature and moisture. To give an idea of the magnitude of these changes in volume, it may be noted that the difference in barometric pressure between sea level and the height of 3,000 ft. is about 15 per cent. At 5,000 ft. the difference is about 25 per cent. When it is known that gases follow Boyles law, namely that the pressure times the volume is a constant at any temperature, it may be seen that a drop in pressure of 25 per cent is accompanied by an increase in volume of approximately 25 per cent. When a balloon filled with gas rises from sea level to 5,000 ft. the gas in the envelope expands approximately 25 per cent. Similar but slighter expansion and contraction occurs with changes of temperature and moisture. The problem of meeting these conditions has been solved in most cases by the use of ballonets.

Function of Ballonets

When the gas in a balloon expands, the expansion is taken care of for a limited time by the elasticity of the bag itself. Beyond a certain point the bag will not stretch. However, the filling gas may not be allowed to escape in large quantities. Otherwise, when the balloon descends again and the balloon contracts there will not be sufficient lifting power and it will fall. Therefore, balloon builders have placed inside of the gas compartment, air bags called ballonets, which are inflated and deflated as required by a blower in the airship car, in order to compensate for the change in volume of the filling due to the various atmospheric changes. In other words, when a balloon is about to ascend to a certain known height, say 5,000 ft., it will rise with the bag three quarters full of gas and one fourth of air. As the balloon rises and the atmospheric pressure falls, the gas expands, thereby expelling air from the ballonets. This process continues until the maximum height is reached at which height all of the air has been expelled from the ballonets and the balloon is completely filled with gas without having lost any gas. When the descent is made, the gas contracts and the ballonets are inflated from the blower enough to keep the internal pressure of the bag at a certain prescribed point. This internal pressure is usually slightly over atmospheric, being sufficient to keep the bag stiff and to prevent caving in of the nose due to wind pressure and flattening of the side due to the load of the car.

Dilatable balloons were constructed with the idea of eliminating the ballonets. The dilatable feature consists in one or more extra gores being inserted in the bag. These gores fold together, the bag being held tight at all times against internal pressure. As the gas expands the rubber cords stretch, thus allowing the bag to increase its size. This process continues up to a certain limit which limit can be regulated by the length of the rubber cords and the size of the extra gore.

Several types of dilatable balloons have been proposed. Some of these types have been built.

Fig. 1 shows a French type known as the R D. This was a regular type R kite balloon converted into a dilatable balloon by the removal of the ballonet and by the addition of two extra gores, one on either side of the bag, and series of rubber cords.

Fig. 2 shows a type known as the X type. This was a British idea. The dilatable feature was contained entirely on the inside of the bag. It consisted of two series of rubber cords, one vertical and one horizontal, which contracted the bag so that it presented, in a contracted position, in cross section, a four leaf clover.

Fig. 3 shows a type known as the expanding gore research balloon. This type has a simplified system of cords. Otherwise it is similar to the R D.

Figs. 4 and 5 show cross-sections of the envelope of the type known as XX in contracted and expanded position, respectively. The XX type, which was developed in this country, is a combination of the RD and of the X, embodying the dilatable feature of the former and other points of the latter.

Figs. 6 and 7 show details of construction of the dilatable feature. The additional gore, called the expanding gore, is similar in shape to the other gores of the balloon. Eyelet bands, shown in detail, are attached to the balloon as illustrated, and the rubber cords are fastened to the eyelet bands in the order shown.

A type of knot which has been developed for tieing in the rubber cords is shown in detail. This knot does not slip but tightens with a greater load. It allows a quick and easy adjustment of the rubber cord lengths. It is necessary, upon inflation, to adjust the lengths of the various cords so that the balloon will be stressed equally along the entire length of the eyelet bands. Otherwise large folds and puckers appear. An adjustment is necessary also to obtain the proper length of cord to hold the internal pressure of the bag.

Construction Features

Some difficulty was experienced in building the first of these balloons because, in following the French design, the extra gores which are inserted were made shorter than the other gores of the balloon and were stopped off some distance from the nose and tail of the bag with the result that when the balloon was expanded to its full size there was a point of greater stress at either end of the extra gore. This fault was remedied by extending the extra gores to the nose and tail and by making them exactly similar to the other gores of the balloon.

In designing a dilatable balloon our practice was to lay out the gores to fit the balloon when fully contracted and then to insert the extra gores which would remain in a folded position inside of the balloon while the balloon was in a contracted position, but which would fill out smoothly when the balloon was fully expanded. We believe the French designed their balloon to be perfect in a fully expandrd position and in so doing were able to shorten the extra gores without producing a point of stress at the ends. The reason for shortening the extra gores was merely to avoid crossing air ducts at the tail and the nose discs at the nose.

The rubber cords used are made up of several strands of elastic, the whole covered with a braided cotton cover. It is necessary that this cotton cover be very loosely woven in order that the load shall come on the elastic when stretched and not on the cover. Some difficulty was experienced with rubber cords in testing a dilatable balloon built in this country. The cords were too short at various places and as the balloon expanded the covers took the load and broke. The cords must be very elastic and must not receive a permanent set upon stretching. The percentage of elongation of the cords varies with the extent to which the balloon is required to expand. Of course, by putting in wider gores the balloon can be made to expand more and more, in which case the cord is required to stretch further. In ordinary cases the cord is required to elongate about 100 per cent of itself. A good grade of cord will elongate easily about 200 per cent of itself.

Advantage and Disadvantage

There are advantages and disadvantages in this type of balloon. One of the main advantages is the increased capacity for a given size. The elimination of the ballonets makes it

* The earliest known experiments in this field are those of Almerico da Schio, who from 1905 on built several small airships provided with expanding gores.—Editor.

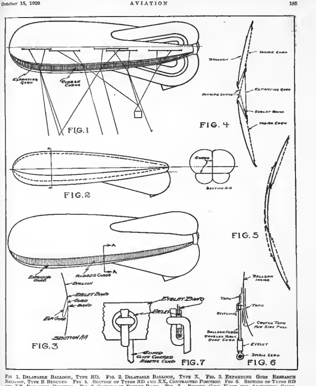


Fig. 1. Dilatable Balloon, Type RD. Fig. 2. Dilatable Balloon, Type X. Fig. 3. Expanding Gore Research Balloon, Type R Reduced. Fig. 4. Section of Types RD and XX, Contracted Position. Fig. 5. Section of Types RD and XX, Expanded Position. Fig. 6. Section of Eyelet Band. Fig. 7. Rubber Cord Knot for Adjusting Cords.

possible to start an ascent with a balloon full of gas. The dilatable feature takes care of the expansion. An R type kite balloon, designed to have a capacity of about 37,000 cu ft., with a ballonet capacity of about 7,000 cu. ft., can rise to a certain height starting from the ground and lift a load corresponding to 37,000 less 7,000 cu. ft. of gas. A dilatable balloon of the same capacity can start from the ground with 37,000 cu ft. of gas and with a correspondingly larger load and can rise to a much greater height depending upon the width of the expanding gore.

Another advantage is the elimination of the ballonet, usually a troublesome thing It is difficult at all times to know just how much air is in the ballonet and consequently it is a hard task to know how high one can ascend. Furthermore there is a leakage of air from the ballonet into the gas compartment which in time reduces the purity of the gas.

Another advantage is that for a given performance the dilatable balloon can be made smaller and more compact than one with the ballonet

Some of the disadvantages are increased wind resistance due to the large number of elastic cords on the outside of the balloon, difficulty experienced in cords breaking, difficulty in adjusting cords.

It would seem there are great possibilities in this idea of dilatable balloons. Several variations of the dilatable gore might be designed and applied not only to observation balloons but also to spherical balloons and airships. A spherical balloon with a dilatable feature might cause a decided advance in the art of free ballooning, in so far as promoting longer flights and higher altitudes is concerned The gas of a free balloon is forced out of the appendix which remains always open When ascending to a high altitude a great deal of gas is lost which must be compensated for by ballasting The carrying of large quantities of ballast reduces materially the margin of lift for passengers.

An airship should be easily capable of being equipped with a dilatable feature, the same being covered in such a way as to eliminate added wind resistance due to the external cords. The advantage of doing away with the ballonets in an airship is of course very great

Development of German Aircraft Engines*

By Otto Schwager

Translated from *Technische Berichte*, by N. A. C. A.

Although considerable improvement in flying efficiency may safely be expected, on account of the low unit weight of the above-named engines, the light-weight engine is not, in itself, a perfect aviation engine, as the latter would be required to supply consistently uniform power up to those altitudes in which the greater part of its existence is spent. In the case of the aviation engines hitherto constructed, power always decreases with altitude until, finally, no excess climbing power is available for the airplane and the limit of its climbing altitude is thus reached

The reason for such decrease of power lies, above all, in the decrease of atmospheric pressure with increased altitude The rotary impulse and the power depend upon the weight of air admitted into the engine, and upon the efficiency of the transformation of fuel energy into engine energy If such efficiency were the same for all aviation altitudes, the engine power would actually depend upon the useful load of the engine and would follow the course of the atmospheric pressure With constant horizontal speed on the part of the airplane, the number of revolutions of the engine would necessarily be the same at all altitudes. As it is, the number of revolutions decreases more or less with increased flying altitude The efficiency of the transformation of the fuel energy into engine power is thereby necessarily lowered. Until quite recently, the decrease of power in its proportion to atmospheric pressure was considered to be a sufficiently accurate basis. Recent tests have proved, however, that the actual decrease of power is considerably greater

Further details were supplied by tests made in the vacuum chamber of the Zeppelin aircraft works at Friedrichshafen, as already reported in Technical Reports, Vol III, No 1, p 1 These tests gave striking proof of the fact that the power of engines does not keep proportional pace with the decrease of atmospheric pressure with increased altitude, and that fuel consumption increases with increasing altitude. The increase of fuel consumption therefore gives the course of the power curve.

High altitude tests made with a Daimler, a Maybach and a Benz engine—the results of which were published in Technical Reports, Vol. III, No 1, p 15—have shown how the increasing fuel percentage of the mixture affects the transformation of fuel energy into engine power. They also showed that the working of the engine deteriorated with increasing altitudes This leads to the conclusion that in developing altitude engines the carburetor and, whenever possible, the efficiency of the transformation of energy should be improved, and that the air inlet should always take place at the same degree of pressure. The object of the improvement of the carburetor would be to supply a mixture of air and fuel that would remain constant under all conditions. In order to be able to do this, however, it would first of all be necessary to give some explanation of the manner in which the carburetor works. It may be assumed, as a leading principle, that air and fuel flow uniformly through nozzles working without friction. This is the case with short nozzles as well as with tapering nozzles, also with throttle valves with sufficiently large orifices. When the fluid passes through long narrow grooves and pipes, such conditions are no longer fulfilled If special attention were paid to this point in constructing carburetors, it might at any rate be possible to ensure only a slight decrease in the number of revolutions of the engine at altitudes, such as is unavoidable on account of the light operating load.

So far as the improvement in the transformation efficiency of fuel energy into engine power is concerned, such efficiency largely depends upon the thermal efficiency. The latter rises with the compression,—that is, with the proportional cylinder volume of the engine + the volume of the compression chamber, as compared to the volume of the compression chamber The compression ratio is, however, limited by the final temperature of compression and the temperature of the cylinder, if spontaneous combustion is to be avoided. For separate methods of engine construction, this limit depends upon the disposition of the cooling-water pipes and more particularly still upon the cooling of the ignition sparks.

These considerations entail the raising of the ratio of compression from normal 4.6—4.9 to 5.8—6.6, and to the introduction of the so-called over-compression engines. With such high ratio of compression, spontaneous combustion occurs even below 2000 m, so that the engines must be throttled up to that altitude in order that they may not be worked at maximum power and that their temperature may be reduced.

In comparison with engines with normal compression, these engines attained considerably better climbing time The first of the type was the Maybach 260 hp engine Its success led to the subsequent construction of other engines for over-compression Conclusive tests were made on several Benz 200 hp engines with regard to the effect of various ratios of compression (see Figs 6 to 9) In Figs. 7 and 9, a comparison is drawn between the registered increase of the mean pressure Δp_m relative to the mean pressure p_m, the ratio of compression being $\varepsilon = 5$ and the increase theoretically calculated by raising the ratio of compression by means of the formula:

$$\frac{\Delta p_m}{p_m} = \frac{\varepsilon^{k-1} - \varepsilon^{k-1}}{1 - \varepsilon^{k-1}} \cdot 100$$

The result of this test is remarkable by reason of the fact that the maximum mean pressure increases when the number of revolutions increases (see Fig 8). It may therefore be con-

* Concluded from our last issue

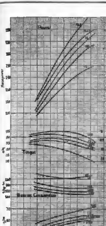


Fig 10 Horsepower, Torque and Fuel Consumption of 200hp Benz Engine No 32524

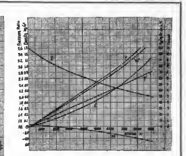
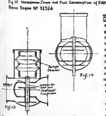


Fig. 11 Power Absorbed by Turbo-Compressor

D = Air Density
P = Power absorbed from adiabatic compression in percent of power output
W = Work of adiabatic compression
T = Temperature at Altitude Δt from adiabatic compression
C = Compression Ratio $\frac{760\,mm}{P_k}$
M = Mean Yearly Temperature



Figs. 13-14 Automatic Regulators for Altitude Engines of The Lorenz Type propeller

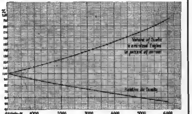


Fig 12 Increase of cylinder Stroke of an over-sized Engine with Altitude.

cluded that increased compression ratio is particularly propitious in the case of high-speed engines. The increase in the rapidity of consumption is also due to the fact that the mean effective pressure actually increases, with higher compression ratios, more than might be expected from the theoretical standpoint. In Fig 10, the power, turning moments and fuel consumption of the Benz 200 hp engine, No 32524, are shown with different compression ratios in terms of the number of revolutions. They show that the engine gives bad results with the maximum compression ratio 6, such results being due to spontaneous combustion and already signalled by the variable running of the engine and excessive fuel consumption

Even the adoption of super-compression in connection with carburetors constructed for high altitude does not finally settle the question of the adaption of the aviation engine to its working requirements. An effort must be made to prevent any loss of power at all up to the customary flying altitudes There are two ways in which this might be done, and which amount to practically the same thing, by inducting fresh air into the engine at constant pressure,—that is, at ground level pressure —or at the pressure prevailing at the altitudes up to which the power is to remain invariable The first method entails the construction of a preliminary compressor in the form of a turbo or positive blower, the second entails the construction of an engine in which the cylinder dimensions are proportionally too large for the gear, and with its power throttled down to its nominal hp. up to a certain altitude This type of engine may be called "over-sized," or said to have dimensions specially adapted to high altitudes.

German Turbo-Compressors

Preliminary compressors for aviation engines, in the form of turbo-compressors, are either being constructed or being tested in different places. The furthest advanced is that of Brown, Boveri & Co, who have constructed an installation for giant airplanes of 1000 to 1100 total hp, at the request of the Board of Directors of the Air Service. The compressor was driven by a special Mercedes 130 hp engine of such dimensions that the total power of the installation remains constant up to an altitude of about 5000 m. Complete tests were carried out with regard to the combined working of a Mercedes 260 hp aviation engine and a preliminary compressor, in the vacuum chamber of the Zeppelin Airship Works at Friedrichshafen, and it was proved that the desired end could be perfectly well attained Flying tests made since that time have also proved the utility of the installation.

About the time that the Administration of the Air Service entered into negotiations with Boveri, Brown & Co concerning preliminary compressors for aviation engines, Schwade & Co., of Erfurth, brought out designs for a turbo-compressor to be directly coupled with a Mercedes 260 hp. engine, and it has been tested at the test-bench. The blower is worked from the rear end of the crankshaft, by means of centrifugal coupling, with 10,000 to 11,000 r.p.m. Such high wheel velocity is requisite in order to obtain the highest possible peripheral speed and to reduce, in consequence, the number of wheels; considering the slight quantity of air exhausted by the compressor, small wheel diameters must be selected to obtain wheels of the necessary practical size. The quantity of air supplied by the compressor is such that the engine power remains constant until an altitude of 3500 to 4000 m has been attained. It was not considered advisable to proceed farther at the time, as it would have necessitated the use of propellers with adjustable blades in order to obtain the full benefit of the improvement, and it was not yet known if they could be successfully applied. In the case in question, propellers of larger pitch were to be used, running at low wheel velocity on the ground but gaining such a high torque that the engine should be as fully charged as at 1400 r p m It is intended that the engine should be correspondingly overloaded by the super-compressor. The wheel velocity should increase with increased altitude and should attain 1500 to 1550 r p.m. at the altitude at which the power remains constant. The advisability of such an overload depends entirely upon the strength and pressure of the surfaces or upon the frictional energy of the gear, by which the temperatures of combustion are not affected. The proof of the possibility of such over-loading has been furnished by tests since carried out at different places. The Schwade blower was installed on an AEG-G-airplane for testing in the air. It is unfortunate that the machine was lost in a flying accident which was in no respect due to the location of the blower

With a view to avoiding oscillations that might arise at the rear end of the crankshaft, in driving high-speed blowers, and which might threaten to cause the utility of the whole installation to be doubted under certain conditions, a blower of equally high power was simultaneously ordered at the Siemens-Schuckert Works, to be driven by the screw end of the crankshaft. Tests made since that time with the Schwade blower show that it is evidently possible to avoid the influence of oscillation on the gear in using hand-coupling or coupling by centrifugal force, although the oscillation itself will not be done away with.

As in the case of fixed engines, tests are also made with turbo-compressors on rotary engines.

In order that the carburetor may be subjected to conditions similar to those of the sea level in the combined working of compressor and engine, the float chamber must be placed under blast pressure When the gasoline is supplied under pressure, the tank is subjected to the pressure of the compressor as well as to the usual pressure of 0 25 to 0 3 It is preferable, however, that the tanks should not be subjected to pressure and that the gasoline should be supplied by means of pumps.

Fig 11 shows the power absorbed by the above-mentioned turbo-compressor In order to maintain constant engine power up to an altitude of 6000 m, 8 8% of the engine power was required. Being relatively small, that quantity can be taken from the engine without any difficulty, by means of overloading Consideration must also be given to the fact that an increase of power at 6000 m is added to the engine power on the ground because the engine only exhausts at an atmosphere of about 0.5, while it becomes charged at a pressure of 0.5, that is, during the time that the suction stroke acts as a compression engine. If, therefore, the pressure in front of the carburetor is to remain constant until high altitudes are reached, by preliminary compression, the engine power must not merely remain constant but must also increase. This has been positively proved by the results of tests carried out in the vacuum chamber at the Zeppelin Works at Friedrichshafen.

Oversized engines proved to be more simply adjusted than those with preliminary compressors. All complementary building parts are unnecessary with the exception of a regulating device to be installed in front of the carburetor There can be no doubt but that this engine will come to the fore in the future, although the preliminary compressor may have the preference for its comparatively high power at altitudes of 6000 and 7000 m. At the present early stage of development, it cannot yet be definitely stated at what altitude the preliminary compressor has the advantage as regards weight. Up to 4000 m., however, the over-sized engine is certainly preferable in respect of weight and construction. The circumference of the cylinder stroke naturally increases with altitude in the case of the over-sized engine, until the altitude is attained at which the power is to remain constant (see Fig 12)

The Possibilities of Super-Compression

In this figure, the necessary increase of volume of stroke is shown without the possibility of any additional super-compression being taken into consideration. If super-compression is employed at the same time, the volume of the strokes is materially diminished. Below 4000 m., the increase of weight through increased stroke volume, and the lengthening of the total construction thereby necessitated, would appear to exceed the weight of a preliminary compressor. The question cannot, however, be determined by considering the weight alone. For the present, greater safety in working and more convenient inbuilding may rather be expected of the over-sized engine than of the engine with preliminary compressor, as the latter requires to be driven with highly sensitive spur gear with high tooth velocities.

The Maybach engine was not only the first super-compressed engine, but also the first over-sized engine, although its over-size was not so highly developed as in more recent types. The Bavarian Engine Works, Ltd., went a step further with their 185 hp. It resembles the Mercedes 160 hp. engine in weight and constructive parts, and its dimensions are such that its power remains constant up to almost 3000 m. The high degree of compression of this engine is remarkable. It attains 6.7 without the creation of any difficulties. This fact is probably

A French Single Cabin Plane: The Henry Potez Type VII

to be ascribed to skillful induction of the cooling water into the cylinder-head The Siemens and Goebel engines are examples of over sized rotary engines. It was Professor Junkers who first recognized the advantages offered by over-sizing and obtained a patent for the same *

Engines with preliminary compressors and over-sized engines require constant regulation of the pressure in front of the carburetor while climbing For engines with preliminary compressors, the inlet air or in the case of turbo-compressors, the air forced into the carburetor, can be throttled down or allowed to escape through a pressure-valve In over-sized engines, the inlet piping must be equipped with a throttling device which so regulates the pressure in front of the carburetor that it always corresponds to the pressure of the altitude at which the power is to remain constant. It may be done by hand, according to readings of the altimeter, or it may be regulated automatically. The latter method is preferable in so far that there is then no risk of damage to the engine at low altitudes, by inexpert handling

These automatic regulators are constructed like barometric installations. Figs. 13 and 14 show a utilizable plan of the Lorenz type of propeller, which consists of an unloaded double-seated valve It is worked by means of a caoutchouc membrane filled with air at the pressure prevailing at the altitude in question. This membrane is placed in the space in front of the carburetor, in which the pressure is to remain constant. As equilibrium always prevails while the gear is in action, there is similar pressure on both sides of the membrane, inside and outside, and consequently no stress is brought to bear upon it.

In the same way that the float case of the carburetor must be connected with the pressure chamber of the blower in the case of engines with preliminary compressors, so must the float case be connected with the space in front of the carburetor when the engine is an over-sized one. In the same manner, over-sized engines may be overloaded at the start, for a short time If over-sized engines are also over-compressed, the overload can evidently only be carried to such a point as is compatible with safety from spontaneous combustion.

Variable Pitch Propeller

The construction of variable pitch propellers goes hand in hand with the development of altitude engines. Here, too, satisfactory progress has recently been made A design has been furnished by Prof. Reissner in which the pitch is regulated by hand and which has been shown to be utilizable when tested with overloading The Lorenz propeller type given an automatic variable pitch propeller, in which a caoutchouc membrane inflated with air at 1 deg. absolute temperature causes the pitch variation corresponding to the given altitude. This type of barometrical device has the advantage of enabling the requisite regulating power to be easily obtained by the relative dimensions of the membrane. To keep this power as low as possible, the axis of rotation is placed as nearly as possible in the center of pressure. Fluttering of the blades is prevented by an oil cataract.

The firm of Garuda has also taken up the construction of variable pitch propellers and has a most interesting improvement now in hand, the pitch being so adjusted, by means of a centrifugal force regulator and a fore-coupled hydraulic Servo-engine, that the number of revolutions remains constant. The constructive system is extremely clear and summary. Such variable pitch propellers should be an acquisition on normal engines, as they render it possible to fly with a normal number of revolutions during the climb and thus to utilize the engine power to its full capacity. In time of war, the speed of the airplane can be accelerated by compression at the moment of danger just as well as at present, in spite of the constant number of revolutions, the propeller being simply automatically adjusted for larger pitch.

* D R P No. 300007

The Wright Airplane Patents

The following statement was issued on September 11 by attorneys representing the Wright Aeronautical Corporation:

"The Aerial Transport Corporation recently declared that it intended to use in its transport service some of the Handley Page airplanes which the British Government sold to the English Handley Page syndicate at about one per cent of cost. Suit was almost immediately started by the Wright Corporation which owns the Wright Airplane patents, to prevent this use. The United States Judge in Delaware has just decided that there is no need at the present time for an injunction to prevent the use of these English machines as it does not now appear that the Aerial Transport Corporation intends to use these foreign made airplanes. The Judge declared that if in the future, the defendant should use or take any action looking to the use of these planes, the Wright Aeronautical Corporation had the right to apply for an injunction to prevent this."

Navy Radiophone Successful

Capt. George W. Steele, jr, U. S N, commanding the Air Detachment, U S. Atlantic Fleet, has reported to the Navy Department that the transmitting equipment installed on Navy aircraft recently modified to operate on the new standardized wave length, has proved entirely successful under tests. The installation of distant control for ignition system has practically eliminated all ignition noises, both on the trailing antenna for receiving and on the radio compass coil. This reduction of ignition noises permits intercommunication between aircraft in flight for distances up to ten miles.

The Dayton-Wright R.B. Racer

THE DAYTON-WRIGHT CHALLENGER FOR THE GORDON BENNETT CUP (250 HP HALL-SCOTT LIBERTY SIX ENGINE) WHICH IS REMARKABLE FOR ITS CANTILEVER WINGS, CAMBER TRIM GEAR AND RETRACTABLE UNDERCARRIAGE

The Dayton-Wright entry in the Gordon Bennett race shows a decided departure from the usual type of aircraft in the way of wing and landing gear construction The two-fold purpose in designing this racer was. first, to bring the Gordon Bennett cup back to America, and, second, to offer to the aviation world something new in airplane construction and performance.

The wing construction is of the cantilever type provided with variable camber which permits of a low landing speed in comparison with the maximum flying speed. The landing gear is so designed that it can be drawn entirely up into the fuselage. It does not have an axle extending from one wheel to the other which permits of taking off on comparatively rough ground.

A 6 cyl 250 hp Hall-Scott motor installed in a streamline fuselage develops sufficient power to pull the ship through the air at a rate of approximately 200 m.p h

The general dimensions, areas, weights, etc., are as follows.

Dimensions

Span	21 ft. 2 in.
Chord at fuselage	6 ft. 6 in.
Chord at tips	4 ft 0 in.
Overall length	22 ft. 8 in
Overall heighth in line of flight	8 ft. o in.
Incidence	1 deg

Principal Areas

Main wing (including ailerons)	102.74 sq. ft.
Ailerons, rear	23 00 sq. ft.
Stabilizer	14 6 sq. ft.
Elevator	9.6 sq ft.
Rudder	7 06 sq ft.
Balance of rudder	85 sq ft.
Fin	3.00 sq ft.

Weights

Weight empty	1400 lb
Useful load	450 lb.
Total weight fully loaded	1850 lb.
Wing loading per sq ft.	18 lb.
Power loading per hp.	7.4 lb.

Power Plant

Motor—Hall-Scott, 6 cyl. vertical, water-cooled.
Develops 250 hp. at 2200 r.p.m.

Weight per hp	2.2 lb.
Fuel consumption per b.h.p. per hr	.58 lb.

Performance

Landing speed	64 m.p h.
Cruising radius	275 miles
Flight duration	1½ hr
Ceiling	15,000 ft

Equipment

Spark plugs used are AC
Delco Ignition System
Two Miller carburetors.
Foxboro, N.C R and Sperry instruments.
Radiator made by Dayton-Wright Co. using tubes manufactured by U S. Cartridge Co
Tires made by Goodyear Tire & Rubber Co.
Wheels made by Dayton Wire Wheel Co
Veneer furnished by National Veneer Products Co.
Celluloid in windows furnished by E I Dupont de Nemeurs Co
Aluminum Cowling made by Dayton-Wright Co. from aluminum furnished by Aluminum Co. of America.
Propeller made by Hartzell Propeller Co
Shock absorber cord furnished by J C Wood Elastic Co.
Clock furnished by Waltham Clock Co
Valspar varnish made by the Valentine Co
White lead made by Carter White Lead Co.
Aluminum made by the Bronz Powder Works.

N. A. C. A. Report

PRESSURE DROP IN RADIATOR AIR TUBES Synopsis of Report No 88, National Advisory Committee for Aeronautics.

This report describes a method for measuring the drop in static pressure in air flowing through a radiator, and shows (1), a reason for the discrepancy noted by various observers between head resistance and drop in pressure, (2) a difference in degree of contraction of the jet in entering a circular cell and a square cell, (3) the ratio of internal frictional resistance to total head resistance for two representative types, (4) the effect of smoothness of surface on pressure gradient, and (5) the effects of supplying heat to the radiator on pressure gradient.

The fact that the pressure gradients are found to be approximately proportional to the square of the rate of flow of air appears to indicate turbulent flow, even in the short tubes of the radiator.

Waterman Type 3-L400 Airplane

The latest product of the airplane manufacturers of Southern California is the Waterman three place De Lux airplane recently completed and tested at Venice by the Waterman Aircraft Manufacturing Company, a description and general specifications of which appear below.

GENERAL SPECIFICATIONS

Motor, 400 hp. Liberty
Weight, empty 2800 lb
Weight loaded, 4135 lb
Useful load 1335 lb
Speed max. 126 m p h.
Speed landing 45 m p h
Speed, cruising 105 m p h
Climb 10 000 ft in 8 min
Ceiling, pilot only, 30 000 ft.
Ceiling one passenger 25 000 ft
Ceiling, two passengers 22 000 ft
Loading, per sq ft 8 9 lb
Loading, per hp 10 3 lb
Spread upper and lower 43 ft. 8 in
Chord 5 ft 3 in
Total lifting area, 475 sq ft
Wing curve R A F 15
Gap, 5 ft 1 in
Stagger 26 in
Dihedral, none
Sweep back none
Range, full speed 800 miles
Range, cruising speed, 600 miles

AREAS

Ailerons, 4	60 sq ft
Elevators 2	25 sq ft
Horizontal Stabilizer	18 sq ft
Fin	8 sq ft.
Rudder	13 sq ft.

WEIGHTS

Fuselage complete with seats, tanks, controls, instruments and accessories	700 lb
Motor complete with ignition battery and propeller	880 lb
Radiators	125 lb
12 Gal water	75 lb
Tail surfaces	90 lb
Self starter and battery	85 lb
Landing gear	135 lb
Wings struts ailerons, fittings and wires	718 lb
Total weight, empty	2800 lb

Throughout the design the machine closely resembles the well known Army type Le Pere, but in detail, general arrangement and wing area there is considerable variation to meet civil requirements. This machine has been designed to particularly meet the requirements of high speed, long range, high rate of climb, low landing speed, all combined with a high factor of safety and luxurious appointment.

GENERAL VIEW OF THE WATERMAN TYPE 3-L400 TOURING AIRPLANE

Fuselage

The fuselage is of the rectangular veneer type with bulkheads and longerons. There are four longerons, ash in front spliced to spruce in the rear These are attached to five bulkheads of eleven ply poplar and birch veneer The bottom and sides of the fuselage are covered with mahogany and poplar veneer which is five ply in front and three ply in the rear This covering acts not only as the tieing member between the longerons and the bulkheads, but as the chief load carrying member of the fuselage construction. The vertical force is also transmitted through diagonal spruce members from upper to lower longerons between bulkheads. As the covering veneer is in one sheet, it was necessary to construct a large press to make these panels. All veneer work in the machine is special stock, using casein glue. The veneer is fastened to the longerons and bulkheads with casine glue and brass nails and screws. The center section struts are of the picture frame type and are built into the fuselage. They extend to the bottom longeron and completely surround the ends of the lower wing beams. All the cowling is of three ply mahogany veneer with one ply of muslin.

The motor is mounted on ash sills which rest on two bulkheads and protrude through the rear one and act as a mounting for the main gas tank. The motor cockpit is completely encased in an aluminum fire pan, with suitable drains. Aluminum cowling completely covers the motor Side type radiators are used. They are set at an angle of 27 deg to the vertical and are provided with shutters which can completely cut off the flow of air The top tanks of the radiators are set into the nose of the upper wing, and conform to its shape. Twelve gallons of water are carried in the whole cooling system

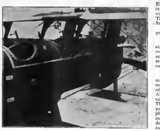
Wings

In construction the wings do not vary greatly from the conventional practice The beams are spruce of the customary "I" section All webs are of ⅛ in. three-ply mahogany and poplar with ash capstrips. The rib spacing varies from 9½ in to 10½ in There are four compression struts to each wing All internal wiring is double, 3/16 in. tie rods being used Three-ply mahogany veneer covers the nose. No stringers have been used, but in their place four rows of cotton tape wrapped three times around the web and capstrip, and then from one rib to the next from top to bottom and vice versa The covering is of Grade "A" linen with the rib sewing reinforced with selvage tape Seven coats of dope and three of varnish cover all surfaces.

Both interplane and center section struts are of the picture frame type built of five-plys of spruce. At the corners, the direction of grain of the second and fourth plys is 45 deg to the vertical. The direction of grain at all other places is parallel to the member itself. This construction entirely eliminates all stagger or incidence wires. Eight brackets bolted to the strut attach it to the beam through bolts completely clamping the beam. The conventional system of wiring is used. Every wire in the machine is double with the exception of the four drift wires.

Landing Gear

The under carriage does not differ widely from the types used on heavier machines. There are three struts on each side of seven-ply laminated spruce. Each set is made up as a unit with the second fourth and sixth plys having a cross grain at the bottom Tubular shock absorber carriers are mounted on the struts and axle parallel to the direction of flight. At



THE COCKPITS OF THE WATERMAN TYPE 3-L400 TOURING AIRPLANE

the lower rear portion of the struts there is a steel band connecting the two struts. To each end of this are fastened four wires which lead to the lower intermediate strut stations. This forms a very rigid truss, the wires at various times taking lift, landing and drift stresses. A 2¼ in. axle and 800 mm × 150 mm tires and wheels are used.

Ailerons

A rather unique system of aileron control is used. The ailerons themselves are built entirely of steel tube. The beam is 1¾ in. by 18 ga. and the ribs ½ in. 20 ga., while the trailing edge is ⅜ in. 16 ga. The whole is hinged on three 1¾ in. × 2 in. bearings. The beam of the lower aileron is connected to a 1¾ in. tube by a dog joint at its butt. This tube runs parallel to the wing beam to the center of the fuselage through two bearings. To the inner end of the tube a twenty-four tooth bevel gear is attached by means of a taper and key. This gear in turn engages with a twenty tooth bevel gear mounted in a similar manner to the end of the stick control shaft. Naturally the weight of each pair of ailerons balance each other and the result is a smooth light running, fool proof control. The upper ailerons are attached to the lower ones by an adjustable push and pull rod.

Tail Surfaces and Skid

All of the tail surfaces are of steel tube of similar size and mounting to the ailerons. The control of the rudder and elevators is by the customary horn and wire method. Both of these units are well balanced and work very lightly. The stabilizer is adjustable and of the neutral lift type. It is hinged from the rear with the front attached to a shaft upon which is cut a coarse thread. This engages with the thread on a bronze drum which in turn is connected with a hand wheel in the pilot's cockpit.

A large metal housing bolted to the lower longerons at the tail post carries the skid. It merely consists of a three-leaf spring secured to the housing and having a suitable shoe bolted to the tip of the lower leaf.

Gasoline System

Gasoline is supplied to the motor by gravity from the twenty gallon center section tank through two ⅝ in. lines which are provided with a strainer and dirt trap. There are three tanks in the fuselage, one carrying 65 gal. and the other two 20 gal. each. Two gear pumps driven by air screws mounted below the fuselage pump the fuel from the lower tanks to the upper one continuously. A standpipe in the center section tank is connected to a return line to the lower tank so the upper tank is kept full at all times until the supply is exhausted in the lower tanks. A sight gauge is connected to the return line showing the proper functioning of the pumps. Either pump will more than supply the motor. The system is so arranged that either or both pumps may draw from any or all tanks. Likewise the return can be directed to any tank. The absence of air pressure and its accompanying danger of fire and trouble is certainly a great advantage.

The oil is carried in two tanks with a total capacity of 10 gal., mounted directly under the motor.

Instruments

In the pilot's cockpit there are mounted the following instruments: Altimeter, tachometer, air speed indicator, clock, compass, oil pressure gauge, thermometer, gas return gauge and three gasoline gauges. The passengers' cockpit in the rear is equipped with an altimeter, clock and air speed indicator.

Finish and Equipment

Since the fuselage covering is of mahogany, the whole machine is finished to match. All wooden parts, whether mahogany or not, are of mahogany piano finish. Fifteen coats of stains, fillers and varnishes are on all exposed wood parts. All were rubbed down between each coat. All metal parts are nickel plated and polished. The cloth work is left natural. The pilot's seat is wicker with a deep spring cushion. The passengers' cockpit seats two people side by side. It is completely sealed in with mahogany and is luxuriously upholstered in French plush. A cellerette and locker are provided in the dash and a large luggage carrier under the back seat. A plush carpet is fastened to the floor. Both pilot and passengers are provided with laminated glass wind shields with adjustable wings. These are so effective that a passenger can fly in ordinary clothes without goggles or helmet with perfect comfort. The pilot and mechanics also enjoy the luxury of an electric self starter and a dash primer.

The Westland Six-Seater

This British machine is similar to the Westland Limousine in construction, but is larger.

It is fitted with a tail trimming gear so that no ballast is necessary. For heating in cold weather, there is a heating box alongside the center exhaust manifold which introduces hot fresh air into the diffuser box. The principal dimensions are:—

Weight fully loaded	5,550	lb.
Napier Lion engine	450	b.hp.
Surface of planes, ailerons and center section	726	sq. ft.
Span (both wings)	54	ft.
Chord (both wings)	7	ft. 3 in.
Height (overall)	12	ft. 6 in.
Length (overall)	33	ft. 6 in.
Gap	7	ft.
Stagger	9	in.
Incidence	2.75	deg.
Dihedral	2.5	deg.
Tail plane	40	sq. ft.
Elevators	30	sq. ft.
Fin	9.8	sq. ft.
Rudder	15.9	sq. ft.
Ailerons (each)	27	sq. ft.
Propeller	9	ft. 9 in.
Petrol capacity	96	gal.
Oil capacity	7½	gal.
Water capacity	10	gal.
Five passengers and pilot or mails	1,200	lb.

Gordon Bennett Aviation Race

The international 300-mile airplane race for the Gordon Bennett Aviation Cup, which was held on September 28 at Etampes, France, was won by Sadi Lecointe on a Nieuport type 29 (300 hp. Hispano-Suiza) in 1 hour 6 minutes 17 1/5 seconds, or at an average speed of 168.26 miles per hour.

Captain de Romanet, on a Spad (300 hp. Hispano-Suiza), a team mate of Sadi Lecointe, finished second in 1 hour 39 minutes 53 2/5 seconds and was the only competitor beside Lecointe to finish the race.

All the other entries, including the American challengers, were eliminated during the race owing to various circumstances.

The Small Airplanes of the British Competition

First Report on the British Air Ministry Competition for Commercial Aircraft by Edward P. Warner, Acting Technical Assistant in Europe of the National Advisory Committee for Aeronautics. (Excerpt.)

This report describes some of the salient features of the six airplanes entered for the small-machine machine competition held by the British Air Ministry in August, 1920, at Martlesham Heath.

General

The six machines entered were the Avro, Austin, Beardmore, Bristol, Sopwith and Westland. All are biplanes except the Avro, which is the same triplane shown at the Olympia Show. All are single-engined tractors, with fuselages of the conventional form.

The specifications require that airplanes in this class carry not less than one passenger nor more than six, exclusive of the crew in both instances, and the list of entries covers the full range of sizes permitted.

The simplest type entered, in respect of passenger accommodation, is the Austin Kestrel, which has a wide fuselage seating one passenger beside the pilot, there being no cabin or covering over the cockpit. The next step upward is represented by the Beardmore and the Bristol, each of which carries only one passenger in addition to the pilot, the passenger being inside a cabin while the pilot is in the open. In the Beardmore the passenger sits in front of the pilot, in the Bristol behind. In neither case is there a real cabin, nor is there any door cut in the side of the fuselage, the extent of the protection being simply a hinged cover swinging over the passenger's cockpit, and access to that cockpit being gained by a ladder. The seating accommodation of all these machines will be discussed in greater detail later in the report. After this pair comes the Sopwith, in which there is a real cabin with seats for two passengers facing each other, the pilot being in an open cockpit forward of the cabin. The layout of the Sopwith is identical with that of the Dayton-Wright Honeymoon Express. There is no machine entered, in any class, in which the pilot's seat is enclosed, and all the pilots and designers with whom I have discussed this matter are strongly opposed to putting the pilot inside a cabin. They do not appear, however, to have any very good or very definite reasons for their opposition. The fifth machine in order is the Avro, in which there are four seats inside the cabin, two facing forwards and two backwards, and the pilot's cockpit behind the cabin. The Avro, however, has elected to carry only two passengers in addition to the pilot during the trials, although there is a considerable bonus for the carrying of additional weight. Finally, last of the six entrants, comes the Westland, which is similar to but not identical with the commercial machine shown by that firm at Olympia. The Westland carries normally five passengers besides the pilot, who occupies a cockpit behind the cabin and opening into it, so that it might be possible for a passenger to change places with the pilot in the air. In any event, communication between pilot and passenger is facilitated.

There follows a tabulation of the areas and weights, the latter being the result of actual weighings at Martlesham Heath.

TABLE OF CHARACTERISTICS OF THE SMALL AIRPLANES ENTERED IN THE BRITISH AIR MINISTRY COMPETITION

Name	Hp	Wt. Empty	Wt. of Fuel	Weight of Passengers etc	Total Weight	Area	W/A
Austin	160	1850	355	405	2705	417	6.48
Avro	230	2480	828	588	3654	488	7.48
Beardmore	185			400*		549	
Bristol	230	2555	493	400*	3580	565	6.34
Sopwith	180	2367	480	538	3350	551	6.09
Westland	450	3828	738	1200*	5850	728	7.88

*Estimated

Wings and Wing Trusses

With regard to the aerofoil sections employed and the plan form of the wings, four of the six machines entered have sections closely resembling the R.A.F. 15, while the Avro and Beardmore have a more pronounced camber on the lower surface, with no Phillips entry. The tips are nearly square or slightly raked in most instances, the only very marked rake being on the Beardmore, where the angle of the wing-tip is somewhat greater than on the JN. The cutting away of the trailing edge is most pronounced on the Bristol.

The positioning of the spars presents nothing very unusual. On the Beardmore, where there are ailerons on the upper wing only, the spars are placed quite differently in the upper and lower wings, although are of nearly if not quite the same chord. The spars are farther back on the upper wing, presumably in order to decrease the chord of the aileron. The upper rear spar is thrown back farther than the upper front, and the struts accordingly diverge as seen in side view. On the Sopwith and Bristol the aileron chord is decreased still more without the necessity of moving the spars from their most efficient positions by using a false spar, as was the common practice on German machines at one time. This false spar is connected to the spars which enter into the wing truss proper only by the ribs, and its sole duty is to carry the aileron.

In no case is there any overhang. The use of overhang has definitely ceased in England, and it is a little hard to see now that it ever had any real justification anywhere except in very small amount or on a "one-and-a-half strutter" or in connection with Warren truss. As a corollary of the absence of overhang, none of the interplane struts slope outward as viewed from the front, but the center struts do so slope on two or three of the competing airplanes, notably on the Beardmore, where they are inclined nearly 45 deg. There is a little positive stagger in most instances, but nothing excessive. Sweep-back is unknown, but dihedral (usually about 3 deg.) is applied on all wings in all cases.

The trusses are all conventional in general. Stream-line wire is used throughout for all external bracing of the wing truss, and enough confidence in that material is felt so that the flying wires are not necessarily doubled, being single on the Beardmore, Sopwith and Westland. Where the flying wires are single, the landing wire is usually of the same size as the opposed flying wire. This seems to be a rather inefficient distribution of material. The only eccentricity of bracing outside of the center section is in the Sopwith, where a wire runs from the lower rear wing hinge to the center of the inner bay of the upper rear spar. It is believed that this wire is introduced in order to assist in triangulating the structure against rolling moments and to prevent the rear spar from moving laterally at the center section and taking an S-curve, there being no cross-wiring in the rear truss of the center section, rather than to provide an additional point of support for the upper rear spar under normal symmetrically distributed loads. The Bristol and Westland have three bays on each side of the fuselage, all other competitors two. The Avro, of course, has the conventional triplane bracing with only one set of wires for the two bays.

British design is definitely committed to the omission of the external drag wires, the Bristol and the Avro being the only entries with any external drag bracing of any sort. The Bristol has one wire on each side running to the upper front spar, the Avro one to the middle front. The total omission of such wires on four machines out of six is a very encouraging sign of increasing cleanness in design, and it is to be hoped that American designers will follow the example thus set.

Before discussing the center section bracing, the nature and the efficiency of which are largely dependent on the type of strut and end attachments used, something must be said regarding the interplane struts. The steel tube strut is constantly gaining in favor, the Austin, Sopwith and Beardmore employing steel struts throughout, while all the other entries except the Avro use steel tube in the center section.

The center section arrangements in general are of very simple forms. The Austin and Beardmore have three steel tubes arranged in the form of an N on each side of the center section, the drag load being carried through the diagonal tube. The inclined member in the Beardmore runs upward from front to rear, in the Austin upward from rear to front, so

that a normal drag load on the upper wing throws the diagonal into tension in the first case and into compression in the second. There is little to choose between the two dispositions, however, as the drag load is always likely to be reversed in sign by the effect of the stagger wires, which pull the upper wing forward during a dive when the short stagger wire serves to equalize the lift deflections in the front and rear trusses. The other four machines have the usual wire bracing in the sides of the center section. The cross-wiring is complete in the front and rear of the center section in every machine except the Sopwith, where, as already noted, it is omitted from the rear. Extra wires running forward from the center section are rare. In no case are there more than four struts. In most instances the center section struts are vertical, although those on the Beardmore diverge widely and those on the Sopwith slightly. There are no pyramidal or inverted-V cabanes.

The only folding wings are on the Beardmore. In order to increase the rigidity of this machine, and because of the very wide center section, an additional wire has been run directly from each corner of the center section to the corresponding lower wing hinge. This is similar to the arrangement on the Pfalz D. XII, but these wires on that machine replaced the center section cross-bracing.

Fuselages

There is nothing very unusual about the fuselages of any of the competing airplanes. All are of the conventional form, with such modifications as are necessitated by a cabin, and the most interesting constructional feature is the extensive use of steel construction. The Austin and the Beardmore, at least, are all-metal, the Austin being of steel and the Beardmore of duralumin, and the Bristol, Sopwith and Westland also embody a large amount of steel in the construction of the fuselage. The Austin fuselage contains no wires at all, the tubes being arranged in the form of a Warren truss. There is no brazing or welding of joints either in this machine or in the Sopwith, sockets and riveting being used throughout.

Some of the fuselages are very deep, particularly on the "coupes." The fairing on the Bristol rises, at the passenger's cockpit, about 2 ft. above the upper longerons, and then falls away very rapidly, meeting the longerons forward of the tail-plane and giving the machine, in side view, a peculiarly hump-backed appearance.

Engine-support design offers nothing new except in one instance. The Austin engine bed is carried by a triangulated structure of steel tubes, much like that on the Vought, an intermediate support for the engine bearers being furnished by a pressed-steel yoke. The Bristol bed is in accordance with their usual practice, being of the "shelf" type with all structural members except a couple of light radiator braces in the lower half of the fuselage and below the engine bearers proper. This of course decreases the depth and the structural efficiency of the forward part of the fuselage, but it is extremely conducive to accessibility of the engine. The Westland bearers are somewhat similar to the Bristol, the central support for the bearers being furnished by two inverted V's of steel tubing, the bearers resting on the apices of the V's. The V's are closed and the structure triangulated by a tube, with a hinge at its center, which runs across the fuselage. The Sopwith bearers and their support are similar to those on the JN. On the Beardmore the engine-bed is unique, being of duralumin, and the construction is absolutely identical with rigid airship construction. The sections are the same, they are triangulated into lattice girders in the same way, and the riveting is the same. The general arrangement of the assembled members is not unlike the arrangement which would be used with steel tubes. All members are duplicated throughout the fuselage, the factor of safety being double the required value and the rupture of any one member being permissible without collapse or dangerous weakening of the structure, yet the weight is by no means excessive.

It is noteworthy that the Beardmore Co., which has probably had as much experience with structural work in light alloys as any one in the world except some of the Germans, is not at all optimistic with respect to the manufacture of all-metal machines with metal wing covering. The objection is that duralumin is still a tricky material, being liable at times to non-homogeneity which cannot readily be detected when new, and that this diversity of nature through the metal causes corrosion to appear in some parts. The metal wing covering itself is so durable that the internal structure of the wing is likely never to be inspected, and that structure is liable to deterioration. The Beardmore firm has found in the rigid airships that frequent inspection is necessary in order to catch incipient corrosion of the girder members. The trend of opinion in England seems to be toward the scheme adopted by the Blackburn firm in its "aerial tramp," planking the wing surface with strips of veneer, rather than toward all-metal structures.

An interesting point in the construction of the Austin is the fire-wall. Instead of embodying a layer of asbestos sheeting, as is the common practice where any serious attention is given to fire protection, the wall consists of two thin metal plates separated about half an inch, and with louvres in the cowling so placed that cool air is kept constantly circulating between the two plates while the machine is in flight.

The cowling is very good on some of the entries, particularly on the Sopwith, where it closely resembles that on a car in detail arrangement. The engine is completely covered by the pressed aluminum cowl, which is shaped to fit the heads with a clearance of about 1/16 in., and the cowl is held down by a few spring latches, so that it can be removed quite as easily and quickly as on an automobile. Complete cowling of course requires an increase in radiator size, but it gives a very neat appearance to an airplane.

Seating arrangements have already been briefly commented on in connection with the general introduction, but there are a few special features which call for further remark. The Sopwith cabin, the layout of which has already been described, has a sliding hatch over the rear. The rear end of the hatch cover carries a windshield, so that by sliding the hatch forward, the passengers can put their heads out and get the same view with the same protection from the wind that they would get in a cockpit. A number of the competing machines are fitted with stoves on the exhaust and butterfly valves so that air may be admitted to the cabin either from the stove or from the free atmosphere or with the two mixed in any desired proportion, so making it possible to keep a constant temperature inside.

Most of the cabins are fitted with permanent steps or ladders to assist entering and leaving, but the Beardmore has a very neat folding ladder, lying back alongside the fuselage when not in use. The side pieces are channels and the hinged rungs are small enough so that, when folded, the two channels lie snugly together with the rungs between them.

Landing Gears

The question of landing gears is a very vital one in this competition because of the extraordinarily severe requirements as regards landing distance, and three of the six competitors have fitted brakes to decrease the length of run. There are no air-brakes or flap gears here, as these devices appear to be out of favor. Some of the companies have tried air-brakes, but report them a good deal of trouble and of very little use in steepening the glide.

The divided axle has a strong following here, being used by the Westland, Beardmore, and Sopwith. The most reasonable argument in justification of the divided axle is that put forward by the Beardmore designer, who says that it is more satisfactory in side-slipping landing because the axle is definitely held with respect to lateral position.

Two of the landing gears, those on the Beardmore and the Austin are perfectly ordinary in design, the first, as already noted, employing a divided axle, while the Austin gear is substantially of the type used on all American airplanes. The Avro landing gear, too, presents nothing radically new, although it is of a rather unusual type, there being no cross-member between the side-members with the exception of the axle, which is of stream-lined form. The rubber shock absorbers are mounted inside of cases half-way up the landing gear struts, as on the Handley Page. The skid is of such length, and mounted in such a position, that the tail-skid, the rear end of the main skid, and the two wheels all make contact with the ground simultaneously when the machine is at rest. The main skid has a small claw at its rear, and a considerable braking effect can be obtained by pulling the elevator up when taxi-ing, so that most of the weight is thrown onto the two skids.

Of the remaining entries, the Bristol may be taken first as

least novel. The landing gear is a V of the ordinary type, with a continuous axle, but a brake has been added. The brake is of the band type operating on the hubs of the wheels, and is small and well concealed. To prevent the machine from going over on its nose if the brake is applied with excessive zeal, a short skid, if that name may fairly be applied to a member shaped approximately like the bowl of a spoon, is placed under the propeller. This protector is carried by two steel tubes hinged near the lower ends of the landing gear V's, and its vertical movement is restricted by a tube running to the nose of the fuselage. This vertical tube is telescopic and is sprung, in order that the shock of bringing the skid in contact with the ground may not be too violent.

Passing from the Bristol to the Westland, a different type of landing gear, and one which creates an exceedingly favorable impression, is encountered. The fundamental basis of the Westland chassis is a longitudinal beam (not a skid) of I-section, carried by four struts arranged in two V's. The two axles are hinged on either side of this beam. To prevent longitudinal motion of the wheels, a tie-bar is run from the outer end of each axle (just inside the wheel) to a point near the forward end of the longitudinal beam where it is hinged. The layout of the landing gear has the form, viewed in plan, of an isosceles right triangle, with a perpendicular (the longitudinal member) erected at the center of the hypotenuse and prolonged both beyond that side and beyond the opposite vertex. There is a single member running from the juncture of the axle and the radius rod on each side to the fuselage, and this member telescopes near its middle, with the shock-absorbers carried inside a case, as with the Avro and the H-P. At the forward end of the longitudinal beam two more wheels are carried as an auxiliary to come into play when the brake is applied strongly. These wheels are mounted at the ends of an axle about a foot long, which is bound to the longitudinal with crossed rubber cords in the usual manner. The Westland brake is an internal-expanding band on each side of the main wheels, and is applied through Bowden wire. The drums are about 15 in. by 1½ in.

Finally, the Sopwith started with an ordinary V landing gear with divided axle. For the competitions, an auxiliary structure with two additional wheels has been built onto the front. This, instead of being entirely a subsidiary attachment as in the Westland, is practically a copy on a smaller scale of the main landing gear. The wheels are a little smaller, but divided axles are used in the same way and the track of the front pair of wheels is only eight or ten inches less than that of the rear pair. The brake is substantially identical with that on the Westland and seems to be very effective.

The average of the tail-skids is better than it was at Olympia, although one or two of the competitors affect the external pyramidal structure. It is interesting to note that two machines (Austin and Bristol) use helical steel springs for shock absorbing in the tail-skid in place of the traditional rubber cord.

Controls and Tail Surfaces

Like the landing gears, the controls are of special interest because of the provision in the competition rules that all machines must fly entirely self-controlled for five minutes. They are permitted to carry out this test with the controls locked or free, as the entrant may prefer, but, as a matter of fact, locked controls are in the majority. All the machines except one are provided with means for locking the rudder (there were two exceptions, but the Avro people found it necessary to improvise a rudder lock if they were to fly steadily uncontrolled), a majority can lock the elevators, and at least one of the competitors intends to lock the ailerons during the self-controlled test.

To turn first to the form and area of the tail surfaces, all appear to be too thin for the best results either aerodynamically or structurally. As for the plan form, one has almost disappeared from horizontal tail surfaces, the Beardmore being the only entry which has a tail form similar to that of the JN. In general the tips of the tail are nearly parallel to the plane of symmetry, the object being to keep the elevator in behind the tail-plane.

The areas of the control surfaces and tail-planes are tabulated below, measured up roughly and good within about 5 per cent.

CONTROL SURFACE AREAS (SQ. FT.)

	Tail-plane	Elevator	Rudder	Ailerons
Austin	30	22	7.0	54
Avro	26	20	9.5	70
Beardmore	31	23	10.1	61
Bristol	27	19	8.1	62
Sopwith	23	16	8.4	43
Westland	35	29	16.0	95

The average ratio of area of elevator to area of tail-plane is .69. This is undoubtedly smaller than the average would be for a similar group of French machines, but it is much higher than the average German figure and all aerodynamic experiment indicates that the ratio could be reduced to .5 with profit (this figure has been reached on the Sopwith).

The adjustable tail-plane is universally employed, and is of course necessary if the airplane is to fly with free controls. Even if the elevator is locked the longitudinal stability can be much augmented by a proper tail-plane setting. The Austin and the Westland have the fin adjustable as well, but not during flight. The leading edge of the fin can be set over to one side, as in the Fokker, to counterbalance the slipstream effect on the rudder. The Westland has two small fins, one on each side of the plane of symmetry and mounted above the tailplane, the rudder standing by itself with no fin in front of it.

Some measure of agreement is at last being reached on the balanced control question, at least so far as the wisdom of attempting to balance is concerned, although there is still a bewildering variety in the methods employed. The present position is that rudders are nearly always balanced, elevators, never, and ailerons on large machines but not on small. Of the nine machines entered in the two classes of the Air Ministry competition, all have balanced rudders and none have balanced elevators. The three large airplanes and three of the six small ones use balanced ailerons, the three which do so in the class now under discussion being the Westland, Avro and Sopwith. The Westland and Sopwith use the old type of balance with the aileron extending forward of the hinge and beyond the wing-tip, while the Avro employs the auxiliary-surface arrangement. The balancing area is about 11 per cent of the total in the Sopwith and 9 per cent in the Westland, while the Avro carries on each side a single balancing surface about 10 in. above the middle wing, each surface being about 5 ft. by 9 in. and being mounted with the trailing edge 9 in. forward of the aileron hinge. With respect to balanced rudders, it is the general rule to have the balancing portion behind the fin, instead of completely above it as in the DH. The Westland is of course an exception to this. This tendency is carried farthest in the Avro, the rudder of which is approximately circular in form and hinged along a chord of the circle, so that the balancing portion extends over the whole height of the rudder. The rudder vibrated rather badly when released, before a locking device was fitted, and the Avro representatives attributed this trouble to the form and position of the balancing portion.

Analogous to the trend toward relatively smaller elevators is the tendency to decrease the chord of the ailerons. The ailerons on the Sopwith are tapered so that they do not project as far to the rear at their inner ends as the trailing edges of the adjacent fixed portions of the wing. This gives the wing a notched appearance when seen from below. The maximum width of the aileron at its outer end is approximately equal to the distance from the false spar to the trailing edge of the fixed part of the wing. The chord of the aileron at the inner end is about 8 in.

Turning from aerodynamic to mechanical questions, the design of the controlling mechanism is conventional in most instances. The Bristol and Westland still cling to the operating cranks outside the fuselage, but these have disappeared from all the other machines. In the Beardmore and the Austin the cleaning-up process has gone a step further, and practically all control wires have disappeared. The Beardmore has two sets of cranks connected by a steel tube and with a torsion tube inside of the tail-plane. In the Austin wires run from the elevator horns to pulleys inside the tail-plane near its leading edge. They are then led inside the fuselage and thence to the control column, only about 18 in. of each wire being exposed.

On the Bristol and the Beardmore all control horns are cantilevered, no wires running to the trailing edge or the

rear spar of the control surface. It has usually been supposed that this would be impossible except in very small machines, and it is quite an important development if all the wiring of the control surface can be eliminated without dangerous weakness It must be borne in mind, however, that the airplanes built for this competition will never be stunted or pulled out of dives abruptly

Rudder wires are doubled in all instances, and the elevator wires also in most cases.

The elevator popularity of the wheel is greater than might be anticipated from the Olympia show, where a good proportion even of the fairly large machines were equipped with sticks. The Austin uses an incomplete wheel like the one used on the B A T transport airplane

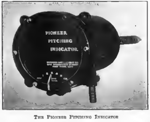
Engines

The engines, as will have been noted from the tabulation of specifications, do not differ much in power with the exception of the Napier Lion used in the Westland The Beardmore and Siddeley Puma are the most popular choices, each being used on two machines. The Beardmore engines of recent manufacture can be started from the seat under any conditions. A special gasoline line permits the simultaneous injection of fuel directly over all the intake valves. The engine can be turned over very slowly through a worm, the crank for which is in the cock-pit A charge having been drawn in this way, a spark is generated in all the cylinders with a hand magneto in the usual manner.

Radiator Installation

Four of the competitors use nose radiators. Of the remaining two, the Austin carries the radiator between the chassis struts and the Beardmore has it mounted in the upper center section The radiator of the Sopwith is exceedingly small in projected area, being made in two vertical strips with a blank space between them immediately above and below the propeller hub, the projected area being roughly a quarter less than that used on the JN4H, although the Sopwith uses a 210 hp. Hispano and the engine is cowled in so completely that there can hardly be any direct cooling.

The radiators are all of the true honeycomb type, except, of course that the Beardmore, which consists of two separate banks of flat tubes about half an inch wide, one bank flush with the upper surface and the other with the lower surface of the wing, the tubes being set at an angle of about 45 deg to the chord The Sopwith radiator uses tubes a little larger, both in diameter and in length, than the standard Air Ministry tubes, the Sopwith elements being about 11 mm in diameter and 130 mm. long, the considerable depth of the radiator accounting for the small projected area required. In the Avro and Bristol, the tubes are not expanded to hexagonal form at the ends, but are left circular, the interstices between the tubes being filled with solder



THE PIONEER PITCHING INDICATOR

Shutters are used in all cases for varying the cooling, the Austin radiator having no device for drawing it up into the fuselage The shutters are of wood on the Austin and Avro, of metal on all the other entries

Exhaust Pipes and Silencers

There are no true silencers fitted, but at least two designs show evidence of some thought having been given to the problem of subduing the bark of the exhaust These are the Austin, which has a fairly short exhaust pipe pinched almost shut at the end and with a number of longitudinal slots cut just short of the beginning of the pinched portion, and the Beardmore, which has a much longer pipe, also flattened at the end but not so much as that on the Austin and without the slots The Avro has a vertical pipe of stream-line section discharging the exhaust above the upper wings, and the effect when the engine is being over-oiled is bizarre in the extreme. The other three machines all have substantially straight exhaust pipes of great length (from 12 to 18 ft) with a free opening at the rear and discharging alongside the fuselage to the rear of cabins and cockpit. In one or two cases the pipe is swathed with asbestos string to reduce the fire hazard from excessive proximity to the fuselage fabric

Turn and Pitching Indicators for Airships

As is well known, the usual line of flight of an airship curves constantly in both vertical and horizontal planes. The big envelope is continually yawing and pitching, and the extra fuel consumed in reaching a destination by this winding route is a very material fraction of the total amount used.

Experiments have shown that both the turning and pitching movements of an airship really start very slowly due to the large inertia of the ship, but that by the time the movement is of sufficient magnitude to be noticed it has such momentum that it cannot be quickly checked It appeared therefore that if the yaw or pitch could be indicated in its incipiency it would be possible to start the counteracting movement of the controls early enough to greatly minimize the undesirable movements of the ship

For indicating the yawing of airships tests have been made with a standard Pioneer Turn Indicator, such as is employed on airplanes, and for the pitching with a Pioneer Pitching Indicator, illustrated herewith. The mechanism of the Pitching Indicator is practically the same as the Turn Indicator, except that it is rotated 90 deg to bring the sensitive element into the vertical plane.

It was found that both of these instruments indicated the beginning of an angular movement several seconds before it was noticeable in any other way By operating the rudder and elevator controls to correct the indicated movements it was possible to reduce the wandering of the ship to a very remarkable extent, with a consequent conservation of power and an increase in the effective air speed.

A further great advantage gained in steadying the ship was the increased accuracy possible in making observations. Ground speed and drift observations were made with very good accuracy as compared to those made under usual flying conditions

It is believed that this system of instruments will rapidly come into use on airships as the economies and advantages are very considerable.

A Letter

The Editor, AVIATION AND AERONAUTICAL ENGINEERING:

With reference to Mr R H Smith's article in AVIATION of August 15, 1920, the existence of an error in resistance measurements on airship models due to the drop of pressure along the axis of the wind channel was noted in experiments made at the National Physical Laboratory in the summer of 1916, and an Advisory Committee Report referring to the matter (R & M 302) was issued in December of that year

The whole subject was investigated as a result of these experiments and in 1918 the writer received reports from the Laboratory in which the correction for pressure drop was definitely determined and allowed for

E. G. WALKER

The Handley Page Wing Patent

The following is an abstract of United States Patent No. 1,35,666 granted September 21 to F Handley Page This is the wing device that has been the object of much secrecy and discussion this year It has been claimed that through its use the commercial transport of passengers and goods will be revolutionized This may well be so if it works out in practice as well as in theory.

In airplane flying machines, the object of the wings and similar members is to deflect the air through an angle so as to obtain the lifting force due to the change of momentum in the air, and it has been found by experience that a thick or highly cambered wing has a larger lift per unit surface than a less cambered or thinner wing, but the highly cambered wing has a disadvantage in that the resistance to passage through air at small angles and at small values of the lift, is large.

Moreover it is already known that when a wing is inclined at an angle to the air through which it passes or which acts against it, that the lift coefficient of such a wing increase with the increase of its angle up to a certain critical angle which varies between 12 deg and 25 deg After this critical angel is passed the value of the lift coefficient of the wing decreases owing to an effect called a "burbling" taking place over the forward portion of the upper surface of the wing, and owing to such action the air flowing over the forward portion of the upper surface of the wing no longer exerts its full suction effort, and this is due to discontinuity of flow between the live air stream and the wing producing a region of eddying air, which above has been termed a "burbling" and which makes it impossible for the full effect of the air suction to be obtained

Now the primary object of the present invention is to provide means or a construction whereby this burbling effect on the back or upper surface of the forward portion of a wing can be overcome, so that the same lift can be obtained at slower speeds than is now possible even when the wing is inclined at a greater angle than heretofore to the air through which it is driven.

For this purpose and according to this invention, the wings and similar members are constructed with a comparatively narrow through slot or, what is equivalent, a series of slots in line, near the nose or front portion, said slot or series of slots extending substantially throughout the wing in a direction transverse to the direction of flight, in order that it or their influence may be exerted at all points of the wing When the wing has such a slot, or series of slots formed integral in its construction, a portion of the said wing obviously forms the front wall of the slot or series of slots, or equivalently such front portion of the said wing may be constituted by a small auxiliary wing, either constructed integral with the structure of the remaining rearward main portion, which latter will be termed the main wing, or constructed separately and connected thereto

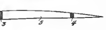
For the purposes of this specification it is therefore to be understood that the portion of the main wing constituting the front wall of the slot or the small auxiliary wing above referred to, are alternative expressions, and such will be referred to hereafter as the auxiliary wing

There have of course been numerous suggestions for airplane construction comprising combinations of wings, arranged in some instances superposed and others in tandem, and in some cases the multiple wings have been of similar, and in others of different, dimensions, but in no case have these wings been so designed as to bring about the objects of this invention, i. e., that the forward auxiliary wing shall so influence the main after wing as to enable the latter wing to be used at greater angles of incidence than it could otherwise have been, without burbling ensuing

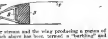
In order to produce this result it is necessary that the auxiliary wing should be set at an angle relatively to the main wing so as to mask its leading portion without being in contact with it, by having the nose of the auxiliary wing at the approximate level of the nose of the main wing, and having its angle of incidence less than the angle of incidence of the main wing.

—FIG. 1.—

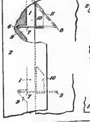
—FIG. 2.—



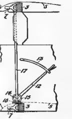
—FIG. 3.—

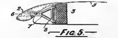


—FIG 4—



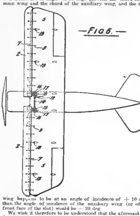
—FIG 7.—





—FIG 5.—

In explanation of said difference in angle of incidence, the chord of the auxiliary wing drawn from the tail to the nose (as indicated by the line A—B in Fig. 1 of the drawings hereafter further referred to) must be at a less angle of incidence than the chord of the main wing. Thus if, for example, there is a difference in angle of 30 deg. between the chord of the main wing and the chord of the auxiliary wing, and the main



—FIG. 6.—

wing happens to be at an angle of incidence of + 10 deg., then the angle of incidence of the auxiliary wing (or of the front face of the slot) would be — 20 deg.

We wish it therefore to be understood that the aforesaid two features of arrangements, namely that the nose of the auxiliary wing shall be located at the approximate level of the nose of the main wing so as to mask the leading portion of the latter, and that such auxiliary wing shall be at a less angle of incidence than that of the main wing, are necessary characteristics of our invention, and when we speak herein of a slot we mean a slot or its equivalent possessing these features.

It is preferable to make the rear edge of the auxiliary wing (or the portion of the main wing forming the front wall of the slot) terminate at about the same height above the chord of the main wing as the highest point of the camber of each wing.

A wing may according to this invention be constructed or fitted with a plurality of such auxiliary wings forwardly located, one auxiliary wing rearward of the other, and in such case it is preferable that the slot formed between the most forward auxiliary wing and the next rearward auxiliary wing should be of greater dimension in the direction of motion of the wing through the air, than the next rearward slot, so that the most forward slot presents the largest openings on the top and bottom surfaces of the wing and the most rearward slot has the smallest openings.

In carrying out the invention, the opening of each slot formed between the auxiliary wing and the main wing has its opening on the upper surface of the wing at a short distance rearward of its opening on the under surface, and usually the dimension of the opening of a slot on the under surface of the wing in the direction of the line of flight is made greater than the opening on the upper surface.

The walls of the slot or slots, considering a wing section, are preferably curved rearwardly from the lower opening to the upper opening, it being a practical consideration in the construction that the air passing through the slot should be directed with a minimum possible change of direction from the under surface where there is pressure to the upper surface where there is suction.

We have found that by constructing the wing with one or a plurality of slots as above stated, a greatly increased lift coefficient can be obtained by such a wing when inclined at considerable angles to the air through which it is driven. By this construction we are enabled to use a slightly cambered wing of the type possessing a high ratio of lift to drag and at the same time secure the advantages of a highly cambered wing, say on a machine carrying heavy weights, without the disadvantages of such a highly cambered wing which have been above stated.

The invention further provides means whereby the slot or slots formed between the auxiliary wing or wings and the main wing can be mechanically wholly, or partially, opened or closed preferably by the aviator while in flight, and this is particularly advantageous for application to a high performance machine, in which, owing to the normal high speed of landing, the great advantage is obtained of being able to reduce the landing speed by opening the slots, the latter at other times being closed.

It will be understood that when the slots are permanently open the resultant wing is suitable for use on a machine carrying heavy weights, whereas previously to this invention such a machine would have had a very highly cambered wing with its attendant disadvantages, the open slot or slots enabling the wing to be at considerable angles to the air through which it passes and to maintain the lift even when flying at slower speeds than has hitherto been possible.

Where it is desired to construct a wing so that the slot or slots formed between the auxiliary wing or wings and the main wing shall be capable of being closed at will, the auxiliary wing or wings can conveniently be made so as to be capable of being moved into contact with each other and with the rearward main wing, as by pivoting the auxiliary wing to the main wing, or equivalent means may be adopted for affecting closure of the slots when required, the invention not being limited to the mechanical details of the means by which such closure may be effected, but the means should be such that the slots on both sides of the longitudinal center line of the machine are actuated together.

The invention will be further described with reference to the examples of construction shown on the accompanying drawings.

Figure 1 shows by a diagram view, a wing section formed with a single through slot comprised between a front portion or auxiliary wing and a main rearward portion or main wing, said slot extending in length transversely of the direction of motion of the wing through the air, and Fig. 2 is a similar view showing a plurality of such slots according to this invention.

Figs. 3 to 7 show an example of construction of the invention in which the auxiliary wing is pivotally connected to the main wing so that the slot aforesaid can be opened or closed, and also illustrates an example of the means by which such opening or closure of the slot can be effected by the aviator during flight.

Fig. 3 is a sectional elevation of a portion of the wing showing the pivotally connected auxiliary wing in the position taken when the through slot is open. Fig. 4 is a plan view of the same, and Fig. 5 is a sectional elevation showing the pivotally connected auxiliary wing in position when the through slot is closed. Fig. 6 is a plan view of an airplane flying machine constructed with the pivoted auxiliary wing as at Figs. 3 and 4, and Fig. 7 illustrates a means by which the auxiliary wing can be moved so that the through slot can be opened or closed at will by the aviator.

The diagram at Fig. 1 shows a wing section having a single through slot 1 formed between the auxiliary wing 2 and the main wing 5, in which latter, 3 and 4 represent the spars, or what has been explained as equivalent, the wing section has the slot 1 formed between a front portion 2 and a main rearward portion 5, and obviously the auxiliary wing 2, might

be constructed integral with the main wing 5, or might be constructed separately and suitably connected to the main wing 5.

The slot 1 so formed, is located near the nose or front portion of the wing section and extends in length substantially throughout the wing in a direction transversely of the line of flight.

The nose of the auxiliary wing 2 is located at the approximate level of the nose of the main wing 5 and also the auxiliary wing 2 is set at an angle of incidence less than the angle of incidence of the main wing, so as to mask the leading portion of the latter. The slot 1 is formed so that the opening on the upper surface of the wing is at a short distance rearward of the opening of the slot on the under surface, and the slot 1 on the lower surface is greater in dimension in the direction of the line of flight than the same slot on the upper surface.

At Fig. 2 a wing section is shown having two auxiliary wings 2, 2^x forming between themselves and with the main wing 5, two through slots 1, 1^x, the slot 1^x extending parallel with the slot 1 and the slot 1 is of greater dimension in the direction of the line of flight then the slot 1^x.

In order to fully explain an example of a means by which the invention can be carried into effect so far as regards the operation of opening and closing the slot or slots during flight by the aviator, the construction will be now referred to as shown at Figs. 3 to 7.

Referring more particularly to Figs. 3, 4 and 5, the auxiliary wing 2 is carried by arms 7, the rearward ends of which may conveniently be pivoted upon substantially vertical pivots 8, carried from the forward spar 3, of the main wing 5, while the forward ends of the arms 7 carry by approximately vertical pivots 6 the auxiliary wing 2, and by reference to Fig. 4 it will be observed that when the arms 7, of which there are a plurality parallel to each other, are in line with the line of flight, the auxiliary wing 2 is distanced from the main wing 5, and the nose of the auxiliary wing is approximately at the level of the main wing and set at a less angle of incidence than that of the main wing, it will also be observed that the slot 1 is produced which has its lower opening of a larger dimension in the direction of flight than its upper opening, and further that the lower opening is forward of the upper opening, and the walls of the slot are curved rearwardly. It may be mentioned that the auxiliary wing 2 is slotted at 9, Fig. 4, and the front part of the main wing 5 is slotted at 10, Fig. 4, to permit of the angular movement of the arms 7. It will be readily understood that by placing the arms 7 at an angle as indicated by dotted lines at 11, Fig. 4, the auxiliary wing 2 will be closed upon the leading part of the main wing 5 as shown at Fig. 5, while when in the position shown in Figs. 3 and 4 the slot 1 is open, the auxiliary wing 2 thus having adjustment relatively to the main wing after the manner of a parallel ruler.

Various constructions of means may be adopted whereby the aviator may effect the opening or closing of the slots and in the example shown in Figs. 6 and 7 as applied to the construction described with reference to Figs. 3, 4 and 5, the machine is fitted with a hand lever 12 within reach of the aviator, the position of which can be governed by a sector 13 as is well known, and the hand lever 12 is fixed on a shaft 14, which in the instance illustrated at Fig. 6 has fixed on either end a bevel pinion 15.

In the construction shown at Fig. 6 the auxiliary wing 2 is divided centrally into two parts, which when moved to their closing position approach each other at the central division.

Each bevel pinion 15 gears with a bevel pinion 16 fixed on a shaft 17, the upper and lower ends of which are in rigid connection with the arms 7 of the auxiliary wing 2 adjacent to the longitudinal center line of the machine and form the vertical pivots of those particular arms 7.

By this arrangement, considering a biplane machine as at Fig. 7, the auxiliary wings 2 of both the upper main wing and the lower main wing will be simultaneously operated and adjusted in position by the aviator through the medium of the lever 12.

Obviously so as to assure uniformity of motion between the auxiliary wings 2 of the upper and lower main wings, the arms 7 of the upper and lower main wings may be connected at other points by vertical shafts indicated at 18, Fig. 6.

Some Mediterranean Seaplanes

With a Digression on Airscrews

By G. H. Bryan, F.R.S.

At a recent visit to the French naval air station near Frejus, where we were kindly received by Commander Jean de Laborde, we noticed numbers of crates filled with airplane parts which evidently accumulated during the war and were marked "a conserver" (to be kept.) Our visit to this naval station afforded an interesting opportunity for a comparison of the conditions under which aviation is carried on as dependent on climate.

Speaking firstly, however, regarding the accumulation and dumping of stores, Commander Laborde referred to the high cost of labor when repairs were required, and pointed out that under prevailing conditions it was more economical when a machine needed repair to take a new machine from the store rather than to mend up an old one—a view doubtless held by many others similarly placed.

In regard to the general problem of seaplane navigation patrol, it is evident that Commander Laborde is confronted with conditions differing considerably from those prevailing in England. Low lying fogs are very rarely met with on the northern shores of the Mediterranean where clear skies and bright sunshine occur often for weeks at a time. On the other hand, the tempestuous character of the Mediterranean Sea has been known and commented on from the earliest historic times. Consequently there are many days well suited for flying on which the waves are so rough that the floats of an ordinary sea plane would soon be dashed to pieces by them. For this reason Commander Laborde has concentrated his attention mainly on experimenting with types of flying boats sufficiently strong to stand a good deal of knocking about in the waves. On the other hand he is very anxious to obtain a really efficient type of machine which can make a descent either on land or on the water.

While the flying boat type has thus been found best to meet the requirements of Mediterranean navigation, it is not very suitable for torpedo practice and for this purpose Commander Laborde had retained an airplane of a type forming a kind of connecting link between the flying boat and ordinary seaplane. It is supported when in the water by two strong boats, but the fuselage which is in the center is raised above them the torpedo being carried directly underneath it and also on a higher level than the boats.

We were next shown a biplane that was being experimented on, fitted with three engines and screws, two of them tractors at the sides and the third being fixed behind them in the center. In this machine which appears to be an Italian make, it was found that considerable loss of efficiency was caused by the slip-stream of the front screws affecting the rear one. In discussing this point Commander Laborde maintained the view that this loss of efficiency does not occur when two propellers revolving in the opposite directions are placed *directly* one behind the other, and he considered that this was a well known fact. It was, moreover, not necessary that the screws should have different pitches, and the arrangement as he pointed out, possessed the advantage of not requiring differently constructed engines for the two screws since two similar engines pointing in opposite directions would produce rotations in contrary senses.

I was very glad to learn Commander Laborde's opinion on this subject because so many practical men have condemned the tandem propeller on the ground of loss of efficiency, although

on general grounds it ought to be the ideal arrangement to be aimed at. Of course the problem of airplane steering, stability and control generally would be greatly simplified if we could get rid of not only gyroscopic action but also of the interdependence of the longitudinal and lateral motions arising from the rotation of a propeller in a definite sense and the effect on the components of air resistance. Practical men tell us that these effects are unimportant, but what is usually unimportant may give trouble in a sudden emergency.

But at the risk of enunciating theoretical views which may fail to be realized in practice I feel justified in now giving expression to a long felt opinion, namely that so far from loss of efficiency it should be possible to obtain considerable increase of efficiency by the use of compound airscrews, although this might involve considerable changes in the form and construction of the screws themselves. It would be good at least to point out that the form of propeller which systematic investigations have proved to the the most efficient when acting singly is not necessarily the best adapted for working on the compound principle.

The motion which the blades of a propeller impart to the air may be resolved into (1) an axial component representing the translational velocity of the slipstream, (2) a rotary or tangential component (3) a radial or centrifugal component.

Now with a single screw there are two ways of obtaining increased speed. One is by keeping the pitch small and increasing the number of revolutions per minute, the other is by increasing the pitch.

Both from the experiments at Farnborough in the Summer of 1919 and from my Report on Compressible Fluids, it is evident that the tip velocity of the blades cannot be made greater than the velocity of sound without loss of efficiency, at any rate with a screw of ordinary construction. On the other hand increase of pitch necessarily increases the rotational component motion of the slipstream, the energy of which is all to be regarded as waste.

If now, the air delivered from the front screw is received on a second screw revolving in the opposite direction, it is clear that the axial motion imparted by the former decreases the efficiency of the latter, while on the contrary the rotary component increases the angle of attack at which the air strikes the blades of the rear screw, thereby increasing the pressure and with it the thrust of the screw. It is possible to determine arrangements in which the pitches of the screws and their velocities of rotation are so reached that the two effects neutralize each other in which case there is nothing to be gained or lost by placing the screws one behind the other. I think it is safe to propound the view that the condition may be satisfied in an infinite number of ways, assuming the pitches as well as the speeds of rotation of both screws be regarded as independent variables for the purpose of the problem. This should be evident for the number of these variables exceeds the number of conditions which they have to satisfy.

If the pitch of the front screw be decreased, its presence will have a prejudicial effect on the rear screw, but if it be increased the air will strike the blades of the rear screw at a greater angle and its efficiency will therefore be greater than if the front screw were absent.

The experimental determination of arrangements in which efficiency is neither gained nor lost is essentially a subject for laboratory research.

In order to gain efficiency by this method it will be seen as a necessary first condition that the pitch of the front screw must be high, in fact higher than would otherwise be desirable. This condition will, further render it possible to make the rear screw also of high pitch since the air strikes it at a higher angle than it did previously. The ideal combination to be aimed at as giving the greatest efficiency according to the present theoretical considerations is one in which the rotation generated by the front screw is neutralized by the rear screw, giving a non-rotational slipstream.

But a two bladed screw will not produce anything like uniform rotation in the air in its wake. If two such screws are placed behind each other, and we take the case in which they are revolving in opposite directions, there will be certain positions in which the blades of the second screw meet the wash of the blades of the first, and these will recur when each screw has revolved through 90 deg., giving 180 deg. for the two, but in intermediate positions they will be acting on different portions of air and the tandem arrangement will be ineffective. To secure efficiency it would be necessary to increase the number of blades so as to give a slipstream more approaching a condition of uniform rotation.

The increase of pitch will increase the ratio of torque to thrust, which is a disadvantage of course, but it also enables the angular velocity of rotation to be decreased in proportion to the translational velocity and it is in this direction that a saving of energy is to be hoped for. On the other hand it will enable screws to be used of larger diameter than would otherwise be possible, thus obtaining the necessary thrust from action on a larger volume of air.

Of course the objection arises that by increasing the number of blades we are increasing the resistance due to skin friction, but this objection is counteracted by the fact that owing to the increase of pitch, the blades travel through the air at lower speed so that the frictional resistance per unit area is less.

There remains the difficulty introduced by the radial motion set up by the front screw which tends to drive the air away from the rear screw. The plan which naturally suggests itself is to make the front screw of conical form, placing the blades so that they cause the air to converge towards the axis. If the extremities of the blades were bound together with a ring of wire this would give an arrangement of far greater strength than the ordinary two bladed propeller, at the expense, of course, of the air resistance offered by the wire.

It is necessary to remember that while all this sounds very nice on paper, there may be a hundred and one reasons why it may prove an absolute failure when put to the test. Moreover I should not be surprised to find that all I have said on the subject had been previously said by someone else.

All that can be asserted with any approach to definiteness is that it is not sufficient to take two ordinary two-bladed screws of opposite pitches and place them one behind the other and then rush to the conclusion that the compound principle is a failure without giving it a fair trial. On the other hand I should not be in the least surprised if in a few years time we found engineers eulogistic in their praise of some new invention of the nature of a compound propeller designed on lines more or less closely resembling those I have indicated above. Possibly even the above suggestions may turn out to represent a description of a propeller that is already on the market under a proprietary name.

The main features suggested above as suggestions for a compound airscrew are (1) increased pitch of both screws (2) increased number of blades (3) increased diameter (4) reduction of number of revolutions (5) possible modification of front screw overcoming the centrifugal component of the disturbed air.

Before leaving the subject of airscrews, and closely connected with the Mediterranean experiments, must be mentioned a new feature in the construction of airscrews introduced by Mr Nada, a cabinet maker of Bordighera. Mr. Nada has conceived the idea of enclosing the woodwork of the screw in an envelope of canvas, the whole being covered with the coatings necessary to produce the same smooth surface that is possessed by an ordinary screw. To sew the canvas into the required form it has to be cut of a peculiar shape, which appears to form part of the specification of Mr Nada's invention, I believe.

Whether the canvas coating affects the strength of the screw under *ordinary* conditions of stress and strain I rather doubt. But during the war screws had to be made from any wood that could be got and risks of accidents from flaws in the wood had to be faced under conditions which would have been little short of madness had not the risk of danger caused by the enemy far outweighed any risk due to structural defects. It was quite certain that even a moderately strong coat of canvas would have a marked influence in reducing the weakness arising from a flaw in the wood. But in war we have to deal not with natural flaws but also with attacks from machine guns, and it was found that with the canvas cover, bullets make a clean hole without splintering the blades. Another advantage is the protection which the cover affords to the wood immersed in water, an advantage particularly important in the case of seaplanes. At the time of my visit, Mr. Nada had sent a number of these screws to the St. Raphael seaplane station. All his screws were made by hand instead of being shaped by the machinery that is used in large factories.

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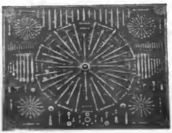

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